

# Variations of the wake height over the Bolund escarpment

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# Variations of the wake height over the Bolund escarpment

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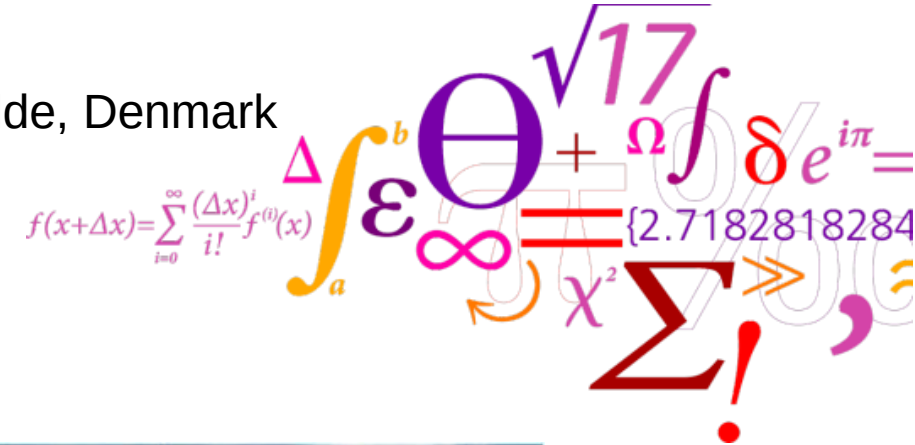


DTU Wind Energy
Department of Wind Energy

# Motivation

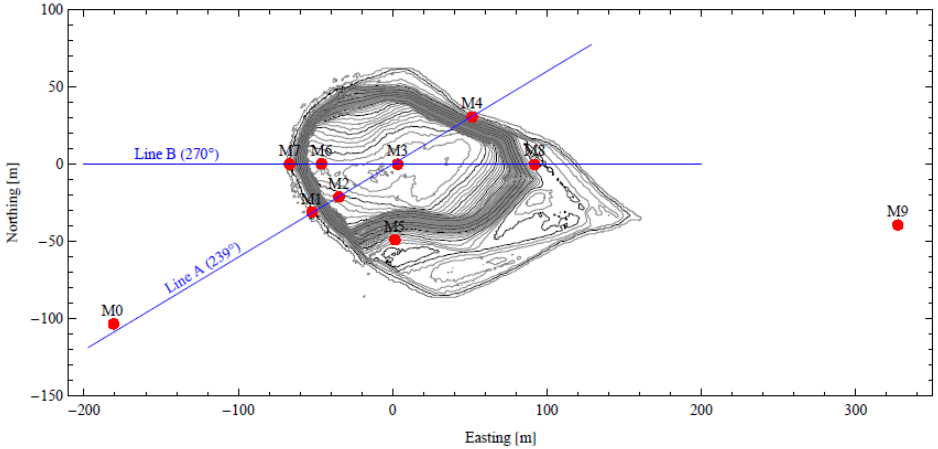
- **Flow over complex terrain** creates complex flow structures that stress wind turbines and influence power production

Woolnorth Wind Farm in Tasmania (© Copyrigh Clean Energy Council)

- Important to characterize flow over complex terrain
- Numerical (CFD,WAsP) and physical (wind tunnel) modelling
  - Real world reference cases for validation

# Bolund in the Roskilde Fjord


# Bolund as a baseline reference case




## Experiment Date:

Dec 2007 – Feb 2008

## Experiment Set-up:

10 masts, equipped with 23 sonics, 12 cups along line A & B, 2 lidars (See: Bechmann et al. 2011,BLM; Berg et al. 2011,BLM)

Flow pattern are observed

+

Well defined boundary conditions, long upstream fetch

=

Ideal for validation of numerical / physical models

# Measurement of the wake zone … With a WindScanner

**Type**

- Laser anemometer
- Windscanner.dk project (DTU Wind Energy)

**Mode of measurement**

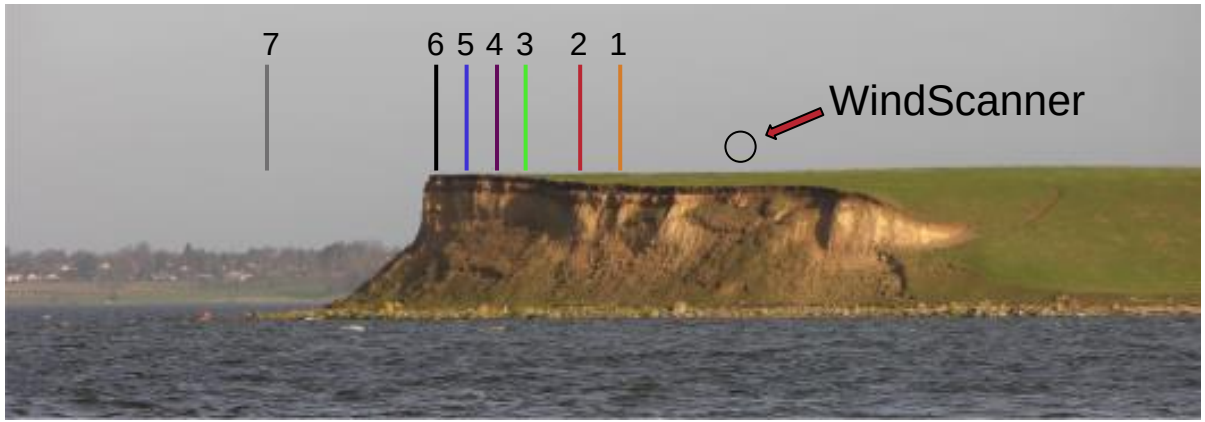
- Continuous wave, coherent Doppler lidar
- Directed by two independently moving prisms

**Output**

- Line-of-sight velocity
- Data streaming rate of 390 Hz


More information about WIndScanner at DTU stand Nr: L07

# Measurement of the recirculation zone




**When**

- October 2011, Duration: approx. 24h

**How**

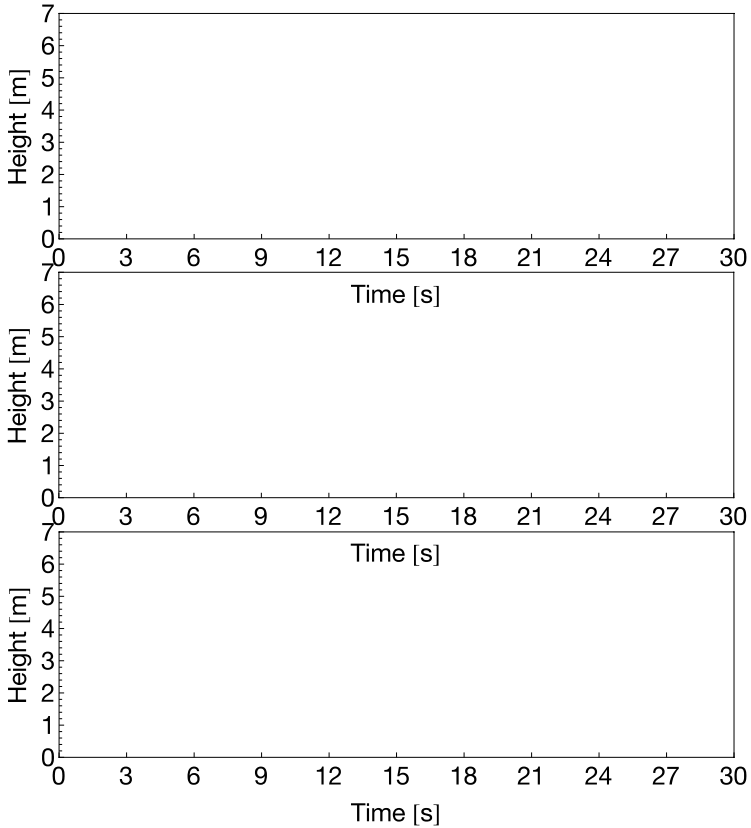
- Positioning 20 m away from the Bolund escarpment
- Aligned to predominant wind direction, on 270° axis, west facing

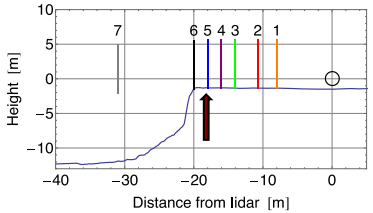
**What**

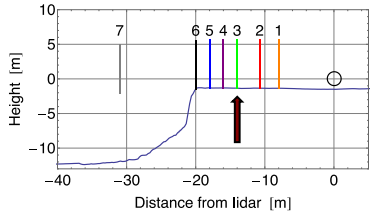
- 7 vertical, 7-m tall profiles
- 1 horizontal arc 90 m upstream of Bolund (definition of inflow)

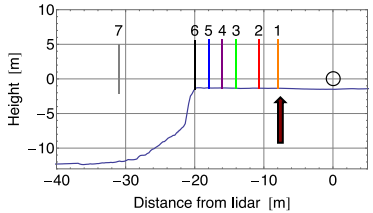
# Half a minute scanning data…

390 line-of-sight velocities per second, 0.1 s per vertical profile



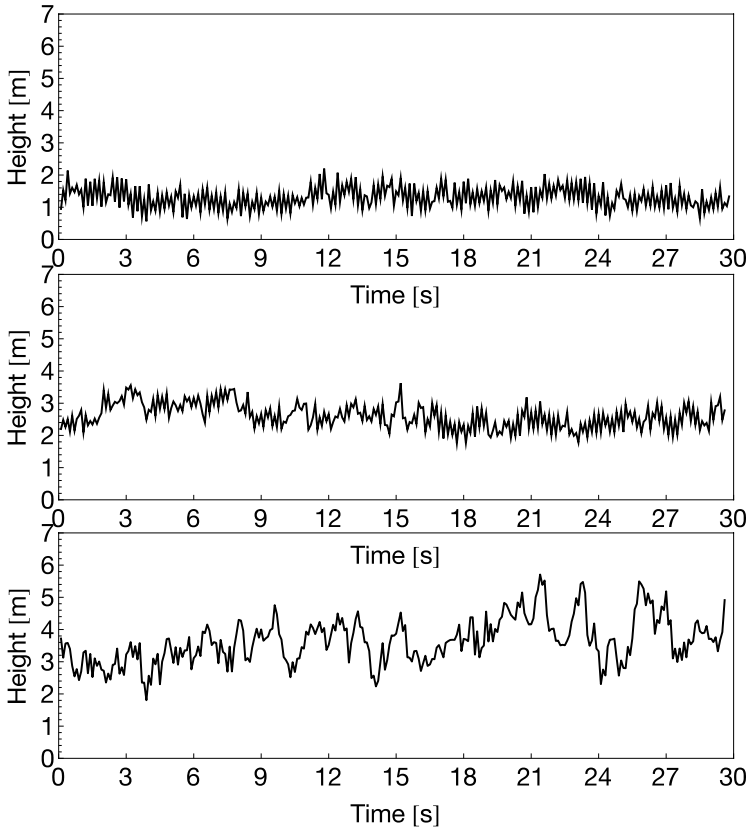



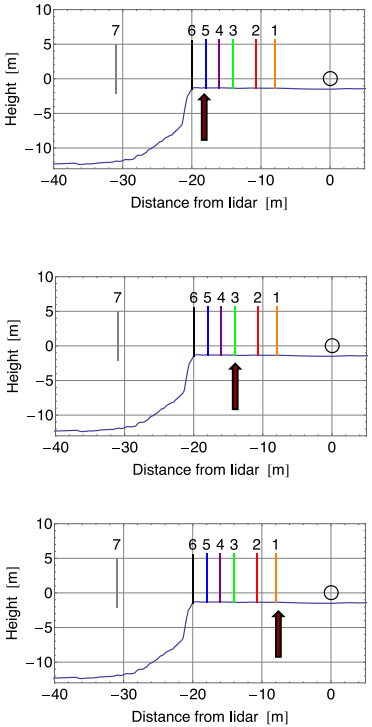



# Half a minute scanning data… with wake height definition

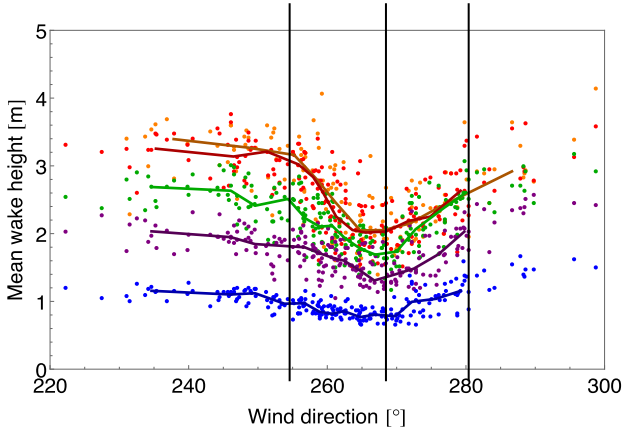
390 line-of-sight velocities per second, 0.1 s per vertical profile



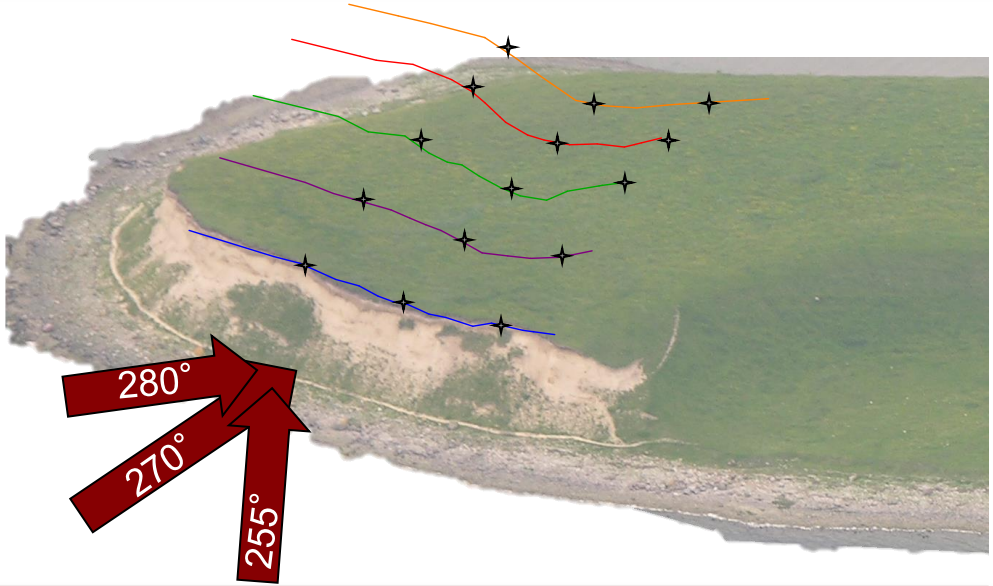




Definition of wake height
➔
average over 30 s scan

# The wake height is highly dependent on the wind direction




Lange et al., Variations of the Wake Height over the Bolund Escarpment Measured by a Scanning Lidar, Boundary-Layer Meteorology.




Wake height dependency on distance from escarpment:

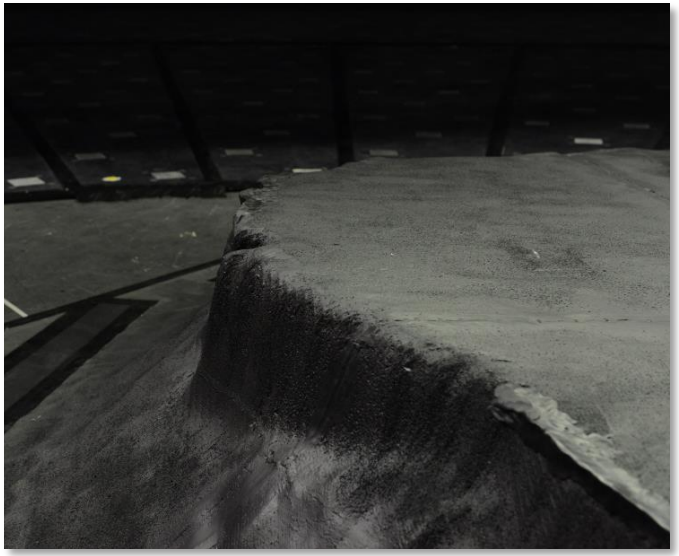
- Increasing wake height with distance from escarpment

Weight height dependency on wind direction

- Wind direction deviation from west ±15° increase of wake height by 10-70%

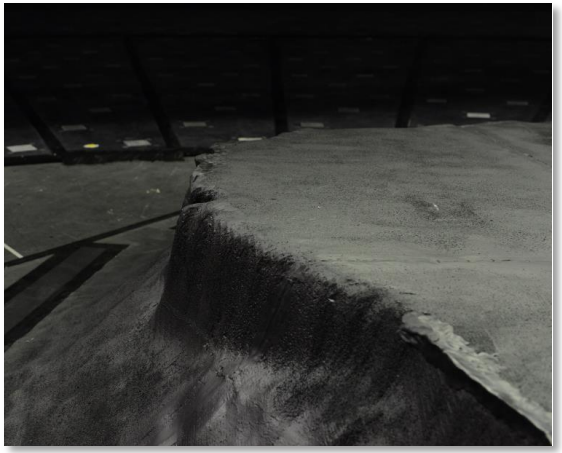
# Bolund in the WindEEE Dome, University Western Ontario, Canada

- WindEEE Dome
- Dimensions: 25m in diameter
- Large scale models, manipulation of inflow and boundary conditions



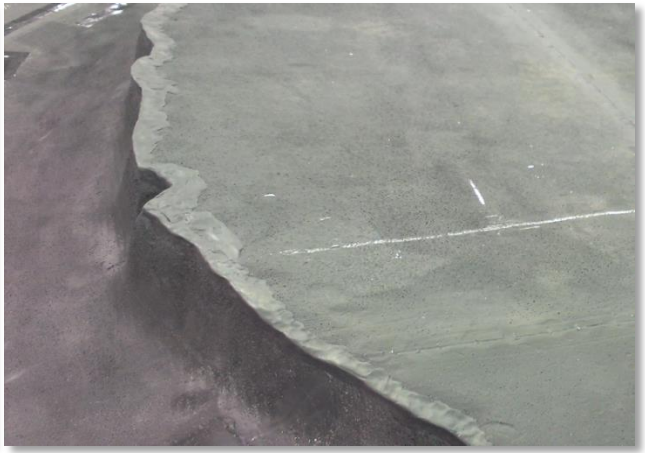
- Bolund model scale: 1:25
- Dimensions: 0,48m high x 3m wide x 4m long

# Comparison of the Bolund edge real world vs. model



Bolund model

Real Bolund



Addition of clay to model edge

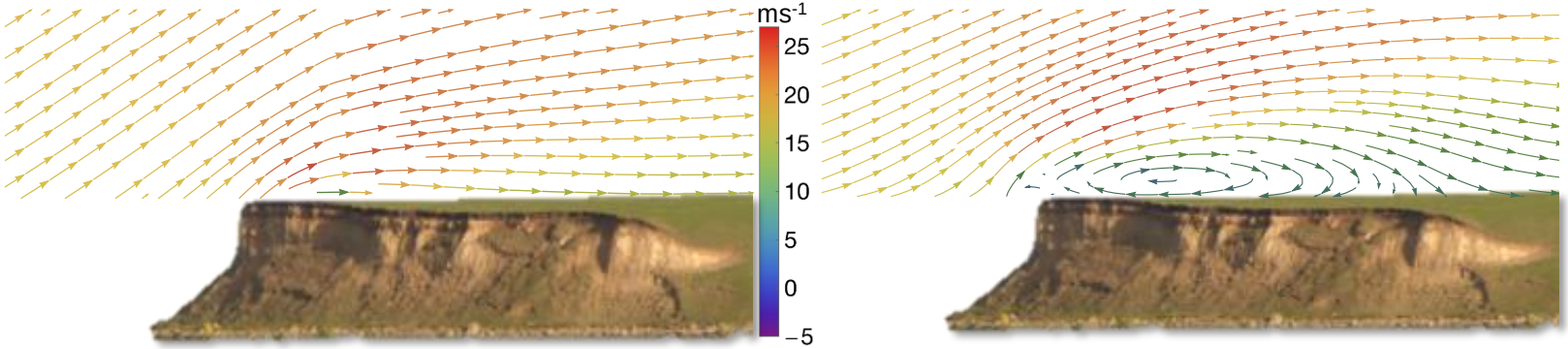
- Model edge is too round
- Model edge is SHARPER

# Flow over original edge vs. sharpened edge

## Flow visualization with smoke



## Measurement (PIV) results




- Smooth flow over edge
- Strong recirculation zone

# Conclusion

- High dependency of wake height on wind direction
- Difficult to reproduce real world flow
- Flow is sensitive to small orographic details, such as the edge

# Thank you for listening